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INVESTIGATION OF HELICOPTER DOOR,  
WINDOW, AND ACCESS PANEL LOSSES

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Naval Air Development Center

Prepared for:

Naval Air Systems Command

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)  Door, window and access panel losses have occurred in a number of helicopters. These losses are costly and cause safety problems to personnel and aircraft. This report describes the investigation and analysis that was conducted to determine the major causes of helicopter panel losses and to identify those panels with high incidence of recurrence. Conclusions have been drawn and recommendations made to improve retrofit and future design of aircraft.		



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S U M M A R Y

INTRODUCTION

This report is intended to identify causes for helicopter losses of doors, windows and access panels and to suggest procedures which will insure that design criteria of future or retrofitted aircraft is based on present day experience.

This task was conducted by the Air Vehicle Technology Department, NAVAIRDEVCON under the sponsorship of the Rotary Wing Aircraft Branch (AIR-5104) and the Mechanical Equipment Branch (AIR-5303) of NAVAIRSYSCOM. The AIRTASK designation was A510-5103/001-4/3510-000-002, Work Unit No. A53032-63.

Helicopter door, window and access panel losses have presented danger to the flight crew and the public in populated areas. In addition, failures of assemblies and fasteners affect the operational readiness of the helicopter fleet. The NAVAIRDEVCON has attempted to define problem areas by correlating data obtained from the NAVSAFCEN, the 3M System, NAVAIREWORKFAC, airframe manufacturers, and operational Navy and Marine squadrons.

RESULTS

Nava. Safety Center

Analysis of 647 reported incidents revealed the following findings:

1. Mechanical failure represented causes for approximately 50% of the losses.
2. Fatigue and vibration were the major contributing causes of mechanical failure.



3. Human error accounted for approximately 30% of the reported losses.
4. Improper pre-flight inspections are at least contributory in approximately 25% of the reported cases.

### 3-M System

An attempt was made to use this data to substantiate excessive maintenance actions for specific assemblies reported from other sources. Generally, the 3-M data verified the frequency of incidents; however, it was found that some specific panels did not require a significant number of maintenance actions prior to failure. In some cases, the size and location of such panels could cause catastrophic results. Thus, the 3-M System may not be a good indicator of pending failure or total consequence of deficient panel design. The lack of failure description of this data source also limits use to its primary intent -- maintainability.

### Naval Air Rework Facilities

Interviews with engineering and shop personnel at NAVAIREWORKFAC Cherry Point and NAVAIREWORKFAC North Island served as a source of input on panel losses. These personnel have a thorough knowledge of a particular aircraft or a particular part of an aircraft. Individually, they have ideas and philosophies for improvements which often cannot be implemented because of time, authority and funding limitations. NAVAIREWORKFAC personnel feel that the majority of access panel problems are personnel related. Except for UR's and random informal contacts, communications between Fleet squadrons, NAVAIREWORKFAC's and NAVAIRSYSCOM for the purpose of improving existing designs appeared limited.



### Airframe Manufacturers

Interviews with airframe manufacturers indicated that design engineers were generally informed on panel loss problems via the company employed Technical Field Representatives. However, this channel of communication is intended primarily to solve present day problems, and not necessarily to provide for future improvements.

### Operational Squadrons

From 34 operational squadrons interviewed, it became obvious that fleet personnel were anxious to communicate informally on local aircraft problems and suggested fixes. Appendices B through F and available trip reports summarize this data. In general, inter-squadron and inter-command sharing of data and fixes are lacking. Effective communication links between the operating squadron and the new aircraft designer are vague to non-existent.

### CONCLUSIONS

Detailed conclusions for each aircraft investigated are described in appendices B-F. The overall conclusions are as follows:

1. The aircraft panel assemblies listed below were found to pose severe hazards to crew safety and mission effectiveness.
  - 1.1 UH-1E - Transmission Cowling
  - 1.2 H-2C/D - Engine Oil Access Cowling
  - 1.3 H-3 - Personnel Door and Engine Cowling
  - 1.4 H-46 - Clamshell Doors On Forward and AFT Pylon
  - 1.5 H-53 - Rotary Wing Pylon Access Panel



2. Communication between squadrons and the airframe manufacturer for the purpose of preventing door, window and panel losses of future aircraft is ineffective to non-existent. Therefore, inferior designs tend to be repeated in new aircraft.
3. Communication methods on door, window and panel loss information between fleet units are not uniform timely or effective. Often, corrective actions implemented in one command are not known to units in another command using the same aircraft. Much effort is thus expended to devise local fixes, not always supported by engineering verification required by NAVAIRWORKFAC or ECP procedures.
4. Since the majority of discrepancies are caused by mechanical failure or design deficiency, improvement in original engineering design practices with in-service follow-up verification of adequacy must be instituted.
5. Pre-flight inspection procedures to insure door, window and access panel integrity must be reviewed to reduce the 25% of losses attributed to improper procedures. Fastener and latch designs which require much effort to inspect, may contribute indirectly to this high percentage.
6. A significant reduction in current failures should be achieved by addressing the following major design deficiencies:
  - 6.1 When hinges are used, they should be on the leading edge opposing the windstream. In the event of fastener failure, the panel would trail in the windstream causing little or no damage.
  - 6.2 Although metal panels are heavier than fiber glass, wood or composite materials, metal should be preferred for safety and maintenance. Excessive flexing of fiber glass panels in flight is considered a significant cause of failure. Grain patterns and the porous nature of wood make wood panels particularly weak and flexible in one direction.



- 6.3 Evidence indicates that a large number of cabin window losses can be prevented with the use of stronger sealants.
- 6.4 Door latch failures can be significantly reduced by insuring that approximately 1 to 1.5 inches of steel rod overlaps the striker plate thereby providing a positive lock.
- 6.5 Externally actuated, internally engaging latches on hatches are unsatisfactory because they fail to provide positive visual confirmation that proper engagement has taken place.
- 7. Aircraft designers of secondary structures such as doors, windows and access panels feel the pinch of weight, volume and structural safety margin restrictions. Usually, after liberal allocations have been made for primary structure, secondary structures must adapt to remaining allocations. Therefore, structural integrity of panels suffer. Since lost panels cause catastrophic failures, prioritizing procedures for allocating weight, volume and safety margin must be reviewed.

#### RECOMMENDATIONS

Prevalent discrepancies reported for specific aircraft are described in Appendices B-F. Specific engineering recommendations for corrective action are not considered within the scope of this investigation.

The following recommendations are made to follow up on the previous conclusions:

- 1. Corrective engineering solutions for the hazardous conditions listed under conclusions paragraphs 1.1 through 1.5 should be solicited by NAVAIRSYSCOMHQ. When determined, corrective action should be applied uniformly to all Navy and Marine Corps Squadrons supplied with similar aircraft.



2. A cognizant focal point at a field activity should be established to rectify deficiencies noted under Conclusions 1 through 7. The purpose of this focal point should be to improve communications, to coordinate and implement assembly and component design actions with safety and maintainability as the major considerations, and to develop design specifications for reliable helicopter door, window and access panels.
3. The following are recommended to improve noted deficiencies:
  - 3.1 An informal source of information which can be within reach of the man on the flight line, depot mechanics, headquarter personnel and aircraft designers. Although the Navy publications "Mech" and "Approach" and formal messages deal with safety, such media do not afford quick, simple communication to and from personnel on the flight line. An autovon hotline and/or postcards may be used to obtain inputs.
  - 3.2 Periodic seminars or workshops involving NAVSAFECEN, NAVAIREWORKFAC's, airframe manufacturers, and squadron safety officers are recommended as a further method to insure two-way dissemination of safety information and new design ideas.
  - 3.3 A governmental in-service Fleet Support Testing Facility to evaluate long term, realistic wear characteristics of door, window and panel design with the intent to provide improved retrofit and new craft designs should be established.



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## INVESTIGATIVE PROCEDURE AND FINDINGS

The basis of this report was an in depth investigation into panel losses or failures incurred with the H-1, H-2, H-3, H-46 and H-53 helicopters. This report is intended to provide a basis for establishing procedures to insure effective design criteria for future and retrofitted aircraft.

During this investigation, data was obtained from the following sources:

- Naval Safety Center (NAVSAFECEN)
- Naval Aviation Maintenance and Material Management System (3-M System)
- Naval Air Rework Facilities (NARF's)
- Airframe manufacturers
- Operational Squadrons

The enclosed appendices have been used to consolidate data obtained from the above sources. Findings have been grouped according to airframe and in order of importance.

### NAVSAFECEN DATA

The NAVSAFECEN reports (references a and b) consisted of brief descriptions of 647 incidents of panel losses for the period of 1968 to 1972. The data included incidents on the H-1, H-2, H-3, H-46 and H-53 series helicopters.



The data was grouped into several categories to reduce the variety of information into a meaningful form. The categories selected were: Basic Causes, Contributing Circumstances, and Major Assemblies Affected. Subcategories and rules for incident classification were also established. The following results are weighted average values obtained from data of all helicopter incidents. For results on a specific helicopter, see the appropriate appendix.

#### Basic Causes

Each incident report was classified into one, and only one, of the following subcategories:

1. Mechanical Failure
2. Design Deficiency
3. Human Error
4. Maintenance Discrepancy

It is apparent that some overlap exists between these subcategories, but a judgement was made based on available data, on the most probable cause.

Figure 1 illustrates the proportional distribution of the results. It is significant to note that the basic causes can almost be equally divided between equipment (1 and 2) and personnel (3 and 4).

#### Contributing Circumstances

The NAVSAFECEN incident reports also revealed a number of other circumstances which were judged significant to note. These circumstances were not always described, but when available or implied,



CAUSES OF THE UNSATISFACTORY REPORTS

H-1, H-2, H-3, H-46, AND H-53 SERIES HELICOPTERS  
(ANALYSIS BASED ON 647 INCIDENTS)

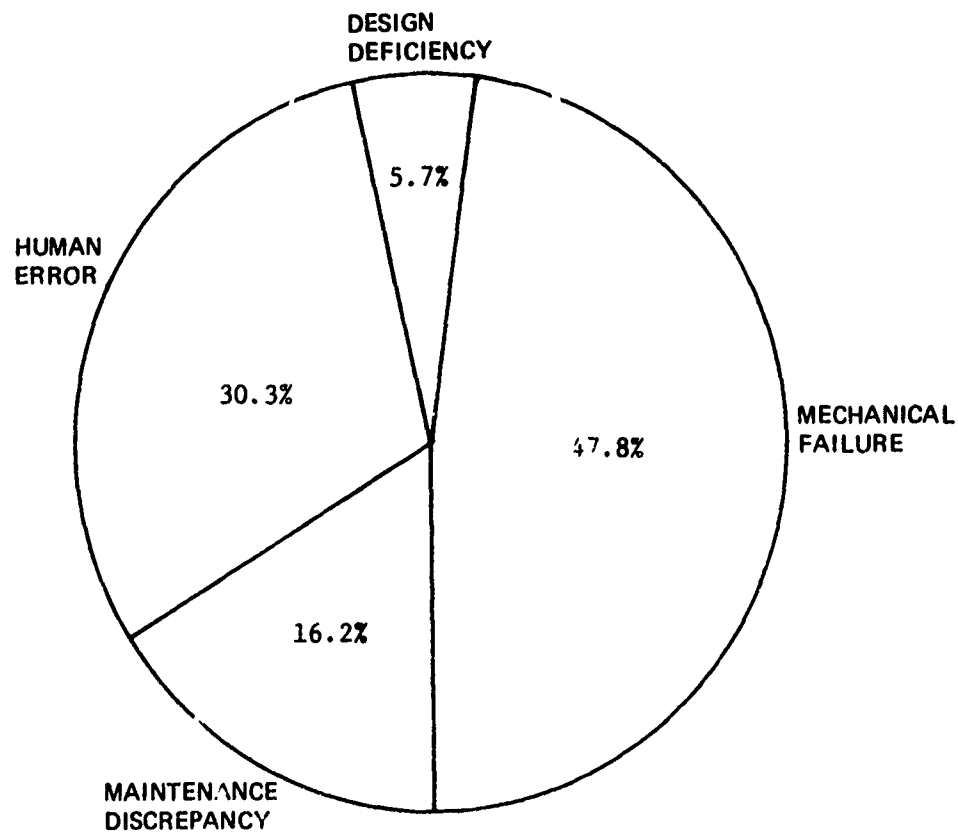


FIGURE 1. GENERAL FINDINGS FROM NAVSAFECEN REPORTS



enteries were made in the subcategories shown. Percentages thus include all helicopters. For results for specific helicopters see the appropriate appendix.

<u>AIRCRAFT STATUS:</u>	<u>%</u>
AIRCRAFT ON GROUND	9.7
AIRCRAFT IN FLIGHT	90.3
<u>CREW PROCEDURES:</u>	
IMPROPER PREFLIGHT	24.7
POOR FLIGHT PROCEDURES	0.9
UNREPORTED	74.4
<u>PHYSICAL CAUSES:</u>	
FATIGUE	1.5
VIBRATION	9.0
UNREPORTED	89.5

It is significant to note that fleet personnel judged improper preflight inspection procedures to be a significant contributor to panel losses.

The high percentage of unreported contributing circumstances may be attributed to limited feedback communication procedures between the fleet and the NAVSAFECEN.



Major Assembly Affected

Each report was classified as to the major assembly affected, for example:

1. Cargo Door
2. Cabin Window
3. Engine Cowling
4. Access Panels

Due to the wide differences in the design of the helicopters, common assembly names could not be chosen. Some helicopters have cabin windows, cargo doors, or specialized engine oil access panels while other helicopters do not. The data derived from this categorization, while complex to interpret, was very valuable both in suggesting the assemblies that needed to be discussed in the squadron visitations as well as providing a wide data base to confirm or deny specific discrepancies. See the appropriate appendix for results on a specific helicopter.

3-M SYSTEM DATA

The 3-M System (reference c) was used to provide sample maintenance action data from the entire fleet. A six month period in 1973 was used as a sample for the appropriate airframe components of the subject helicopters. Data for each airframe component was analyzed to determine the cause/causes of the maintenance action (for example: corroded, cracked, or missing hardware, etc.). The data indicated when the discrepancy was discovered (during preflight inspection, in-flight, or during calendar inspection) and identified, and what action was taken to correct the discrepancy. The data did not



provide a verbal description of each action, but it did provide information identifying major assemblies requiring frequent maintenance. Knowledge of the 3-M Data proved to be an effective tool for initiating direct communication with operational squadrons.

#### NAVAL AIR REWORK FACILITY INPUTS

Direct discussions with engineering and shop personnel at NARF North Island and NARF Cherry Point were also conducted. It was explained that this investigation was not intended to overlap the NARF's responsibility as CFA (Cognizant Field Activity) for a particular helicopter but that this investigation was to take an overall view of the access panel problems on all helicopters with the objective to improve future helicopter design.

NARF inputs differed with those of squadron personnel in that NARF personnel indicated their opinion that the majority of access panel problems are personnel related. NARF personnel feel that there are design and modification principles which can minimize the possibility of human mistakes and they are continuously implementing corrective ECP's (Engineering Change Proposals) or AFC's (Airframe Changes). Unfortunately, due to the time and funding limitations, potential panel improvements can not always be given the priority required for implementation. The NARF personnel could become an important source for new aircraft design practice if an effective channel of communications with the aircraft designer existed. The repetition of inferior design practices, which now may be discovered only after considerable flight time, thus may be prevented. At the present time when experience related problems are discovered, it is too expensive to make specification and retrofit changes. Hence, design practice feedback is restricted.



## MANUFACTURER'S INPUTS

The airframe manufacturers interviewed during this investigation were Boeing-Vertol (H-46), Kaman (H-2), and Sikorsky (H-53). Discussions were held with airframe and structural engineers who were relatively well informed of panel loss problems. The larger companies have a network of Technical Field Representatives located at the operational bases. They communicate present day problems from the man on the flight line back to reliability and maintainability specialists at the plant. A parallel information channel within the Navy between the squadron and the new aircraft designer/specifier is either non-existent or ineffective at best. The existing channels of communication therefore are not considered to be oriented toward preventing bad panel and fastener designs from being repeated in new aircraft. NAVAIRDEVCON possesses the capability to coordinate an information flow effort and has the experience to evaluate all factors involved.

## OPERATIONAL INPUTS

Operational Navy and Marine Corps squadrons provided up-to-date source material on access panel problems. Maintenance and flight personnel provided detailed descriptions of current problems and made specific recommendations and/or descriptions of squadron fixes. Appendix A includes a complete listing of the 34 squadrons and commands visited. During each visit, contact was made with the Safety Officer, the Maintenance Officer, pilots, and crew members. Although the opinions and areas of concern differed widely, there was one area of universal agreement: There is a lack of an effective problem reporting system that enables operational personnel to report their structural problems and make suggestions for improvement. Many



individuals emphasized the excessive formality required to communicate through existing channels such as Beneficial Suggestions, Unsatisfactory Reports, and Naval Messages. In addition, it was pointed out that the feedback to the contributor of ideas was often not satisfactory. The above are considered major obstacles to an effective reporting system.



P R O B L E M   A R E A S   O F   C O N C E R N

GENERAL OBSERVATIONS

Informational sources (NAVSAFECEN, 3-M, squadron interviews, etc.) have been generally in agreement concerning the nature of major helicopter problem areas. Each aircraft model has a few panels which constitute problems or potential problems to that specific aircraft. These access panel problems generally do not carry over from one type helicopter to another. For example, the transmission cowling is a major problem on the UH-1E helicopter. The later model UH-1N and AH-1J aircraft are twin engine versions, and have a distinctly different airframe shape and thus not the same problems.

The degree of emphasis on problem panels have varied according to the data source. Although some panels have not failed often, when they did fail, the results were catastrophic. Typically, these panels did not show up on the 3-M data; yet their failure was important. Other panels have a high frequency of failure but because of size, weight or location, little damage has been caused when they separate from the aircraft.

When a helicopter is lost due to a panel problem, the panel generally separates from the aircraft and strikes the main or tail rotor system causing loss of aircraft control. The movement of the panel at separation is impossible to predict since rotor downwash, airspeed, aircraft attitude, mode of failure, panel shape, etc., all have a bearing on the panel's movement.



Panels that are large, heavy, flexible, or frequently opened have the greatest probability of causing loss of the aircraft.

#### SPECIFIC PROBLEM AREAS

Appendices B through F represent the subject airframes and summarize the findings of this investigation. Access panel problem areas that are unique to specific airframes and pose severe hazards to crew and aircraft safety are highlighted below:

- In-flight failure of the transmission cowling latches is the most serious problem identified for the UH-1E model helicopter.
- Engine cowl access panels on the H-2C/D helicopters have occasionally opened in flight. Two of these cases resulted in fatal crashes.
- In-flight opening of the personnel door and engine cowling on the H-3 aircraft has proved to be the cause of aircraft loss.
- Approximately half of the in-flight access panel openings incurred with the H-46 helicopter are attributable to the clamshell doors on the forward and aft pylons.
- The rotary wing pylon access panel (rotor brake access panel) on the H-53 is a high loss item which constitutes a major threat to safety.

#### DESIGN PHILOSOPHIES

Current aircraft design philosophy can best be summarized with the statement: "When updating an aircraft with a new model,



maintain maximum commonality of parts with earlier models". This philosophy meets the goals of present austerity but it also harbors existing problems that continually go uncorrected. These problems have to be highlighted, corrected and not just passed on to future generation aircraft. A prime example of such an existing condition is the current design of the H-53E port cabin emergency escape hatch which is a carry-over from previous H-53 models. Sources questioned during the investigation have indicated that this particular hatch design is troublesome and a potential hazard.

The H-53 port cabin emergency escape hatch problem is another example why an authority should be chartered to coordinate the safety/performance trade-offs of helicopter design and to receive and disseminate pertinent safety information. Although safety of the crew is of utmost importance, reliability and maintainability (R&M) requirements have to be stressed also. The ultimate goal in establishing design criteria is to provide a helicopter that rates high in performance, is safe to fly and can easily be maintained.

Changes are taking place in access panel philosophy but all too often the changes are not coordinated by any particular group or office. Manufacturers make design changes that working level supply and maintenance personnel are not made aware of. Conversely, squadron personnel have developed fixes that are functional, inexpensive and readily adaptable. These fixes, however, are not generally known by the aircraft manufacturer and incorporated into aircraft design changes. Some design changes are being made to recess components into the airframe and omit the access panels. This design philosophy saves a small amount of weight, cost, complexity, access and maintenance time, yet does not significantly affect the aerodynamic characteristics of the aircraft. Since helicopters are generally low speed aircraft, trade off studies have shown that aerodynamic losses are not great enough to justify making panels mandatory.



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R E F E R E N C E S

- a. NAVSAFECEN Computer Output on H-1, H-2, H-46 and H-53 Panel Losses, 5 Jan 1973
- b. NAVSAFECEN Computer Output on H-3 Panel Losses, 5 Jan 1973
- c. 3-M Aviation Type Equipment History Inquiry, Maintenance Support Office Report No. MSQ 4790.A2097-01, 4 Aug 1973



## A P P E N D I X    A

The following is a complete listing of all operational Navy and Marine Corps helicopter squadrons and offices visited:

<u>Squadron</u>	<u>Location</u>	<u>Aircraft</u>
HS-15	NAS Lakehurst, N.J.	H-3
HC-2	"	H-3
HC-6	NAS Norfolk, Va.	H-46, H-3
HSL-32	"	H-2
HSL-30	"	H-2
VRF-31	"	H-1, H-3, H-53
HM-12	"	H-53
HMM-261	MCAS New River, N.C.	H-46
MAG-26 AIMD	"	H-46, H-53
HMM-162	"	H-46
HMT-204	"	H-46, H-53
HMH-362	"	H-53
HMH-461	"	H-53
HMT-268	"	UN-1N
HML-167	"	UN-1N
HMA-269	"	AH-1J
COMNAVAIRPAC	NAS North Island, Calif.	H-2, H-3, H-46
HC-3	"	H-46
HSL-31	NAS Imperial Beach, Calif.	H-2
HS-10	"	H-3
HSL-33	"	H-2
NAMTD	"	H-2, H-3
HS-6	"	H-3



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HC-8	NAS Imperial Beach, Calif.	H-3
HC-1	" "	H-3
HMA-169	MCAS Camo Pendleton, Calif.	AH-1G
HML-267	" "	UH-1E
Headquarters, 3rd Marine Air Wing	MCAS El Toro, Calif.	H-1, H-46, H-53
Headquarters, MAG-16	MCAS Santa Ana, Calif.	H-46, H-53
HMM-161	" "	H-46
HMM-163	" "	H-46
HMT-301	" "	H-46, H-53
HMH-361	" "	H-53
HMH-363	" "	H-53

Visits were also made to the following helicopter cognizant offices:

NARF	Cherry Point, N.C.	H-46
NARF	North Island, Calif.	H-3, H-46, H-53
Boeing-Vertol	Philadelphia, Pa.	H-46, HLH, UTTAS
Kaman Aerospace	Bloomfield, Conn.	H-2
Sikorsky Aircraft	Stratford, Conn.	H-53A/D, H-53E, UTTAS
U.S. Army Air Mobility R and D Lab	Fort Eustis, Va.	H-1, H-2, H-3, H-53

NAF, Warminster Pa., provided liaison assistance for visits to the above helicopter squadrons and offices.



A P P E N D I X B

H-1 AIRCRAFT FINDINGS

General

The H-1 aircraft are difficult to categorize because the airframes vary a great deal. AH-1 models have different airframes from the UH-1 models and significant differences exist within each particular model. The earlier models are single engine whereas the later models are twin engine. For these reasons each model must be considered separately.

One advantage that the H-1 enjoys over the other helicopters is its size. The H-1 and H-2 are smaller, less complex aircraft with fewer panels to cause problems. A majority of the preflight inspection is conducted from ground level.

UH-1E Transmission Cowling Panel

Information obtained from the NAVSAFECEN computer compilation demonstrated that the Transmission Cowling Panel is the primary problem area on this aircraft. Specifically, material failure of the latch mechanism was most critical. History indicates the need for a positive retention feature for the Transmission Cowling. In-flight Transmission Cowling problems accounted for 55% of the UH-1E reports. Figure B-1 provides a general view of the UH-1E aircraft, and the panel details are highlighted in Figure B-2. Figure B-3 summarizes the findings of the analysis of the NAVSAFECEN reports on the H-1 helicopters.



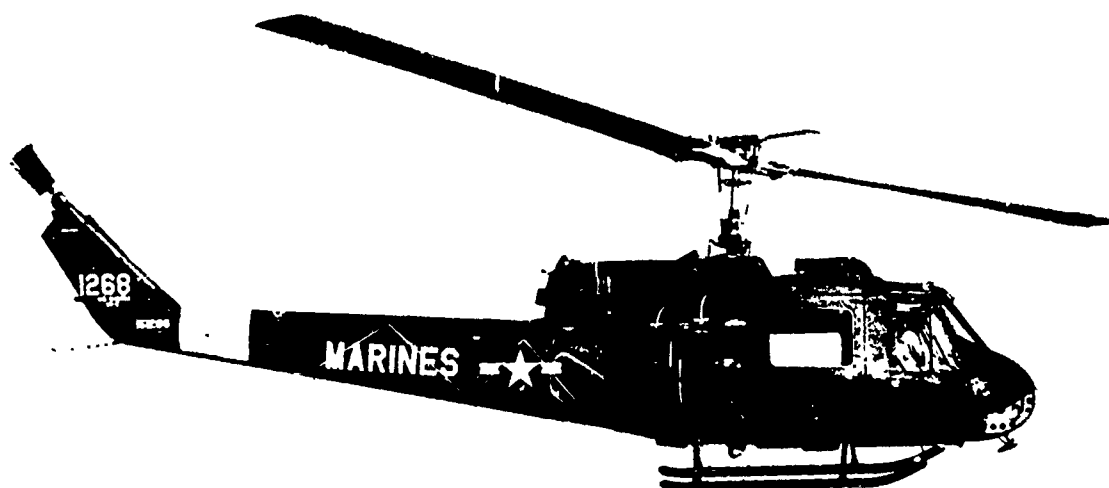


FIGURE B-1. UH-1E HELICOPTER-GENERAL VIEW



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- 1 ENGINE COWL
- 2 TRANSMISSION COWL

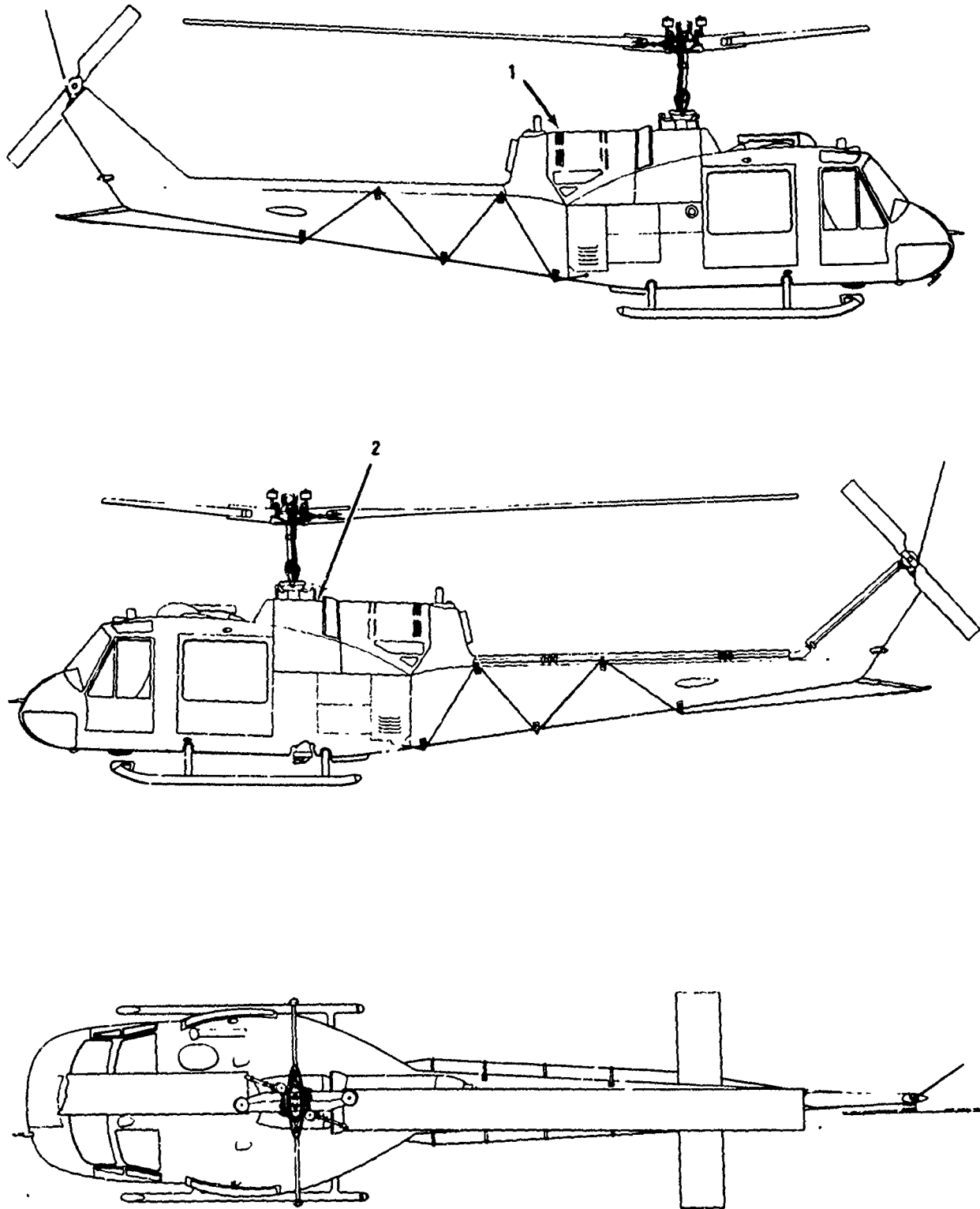


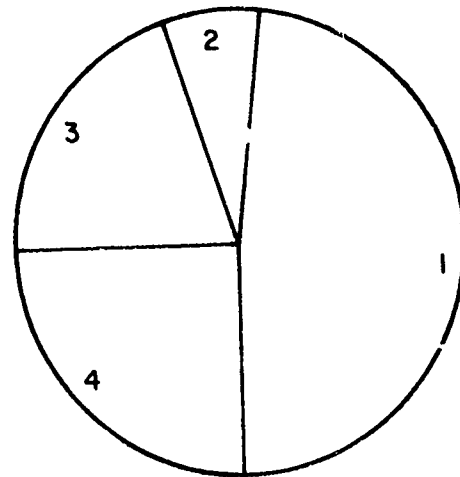
FIGURE B-2. UH-1E HELICOPTER - AIRFRAME GROUP



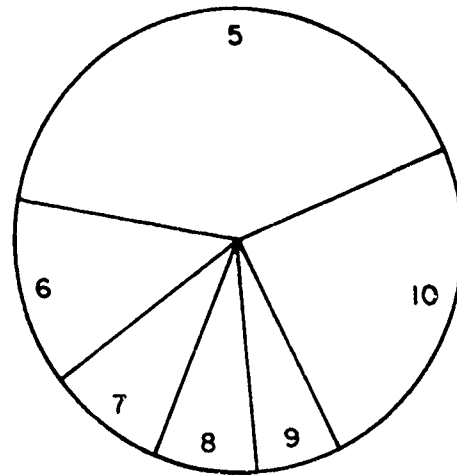
## ANALYSIS OF 102 INCIDENTS

CAUSES

1	MECHANICAL FAILURE	48.1
2	DESIGN DEFICIENCY	7.8
3	HUMAN ERROR	19.6
4	MAINTENANCE DISCREPANCY	24.5

MAJOR ASSEMBLY AFFECTED

5	TRANSMISSION COWLING/DOOR	40.2
6	CARGO DOOR	14.1
7	ENGINE COWLING	9.8
8	CABIN DOOR	7.6
9	TAIL ROTOR DRIVE SHAFT COWLING	5.4
10	OTHER	22.9

CONTRIBUTING CIRCUMSTANCES

AIRCRAFT STATUS:	%
AIRCRAFT ON GROUND	14.7
AIRCRAFT IN FLIGHT	85.3
CREW PROCEDURES:	
IMPROPER PREFLIGHT	17.6
POOR FLIGHT PROCEDURES	2.0
UNREPORTED	80.4
PHYSICAL CAUSES:	
FATIGUE	1.0
VIBRATION	2.9
UNREPORTED	96.1

FIGURE B-3. H-1 SERIES HELICOPTER PANEL LOSSES



UH-1N Engine Cowling Panel

There have been few panel losses with the UH-1N. Whether this desirable condition is due to the relatively few flight hours on the aircraft or simply due to high quality design, construction and maintenance cannot be determined conclusively from the available data. There have been some reports of Engine Cowling losses and these failures have been attributed to improper panel securing prior to flight. The basic metal construction of this aircraft is considered superior to other aircraft since metal panels tend to flex less than fiber glass panels. During the preflight inspection, pilots generally check the metal panels in a rougher manner, and the inspection tends to be more complete.

AH-1J Transmission Cowling Panel

The firing of Zuni rockets creates a low pressure area along side of the aircraft. This greatly distorts the panels on the aircraft and causes panel loss. The Transmission Cowling Panel is most often affected although other panels have separated. Straps placed over the panels or the launching of rockets from outboard stations are some of the squadron fixes to this problem.

AH-1J Tail Drive Shaft Cowling Panel

The Tail Drive Shaft Cowling Panel presents another recurring problem on the AH-1J because the panel is secured by only five Camloc fasteners. The probability of this panel opening in flight increases with maintenance neglect. In most cases, the hinge has been strong enough so that the fiber glass panel remains with the aircraft and bangs against the airframe.



AH-1J Ammo Bay Door

The AH-1J is a later version of the AH-1G. The major problem experienced with this aircraft is the in-flight openings of the Ammo Bay Doors. Squadron personnel have indicated that the doors are occasionally not properly secured and the latches do not have sufficient contact overlap to allow for in-flight flexing and vibration.



## A P P E N D I X C

### H-2 AIRCRAFT FINDINGS

#### General

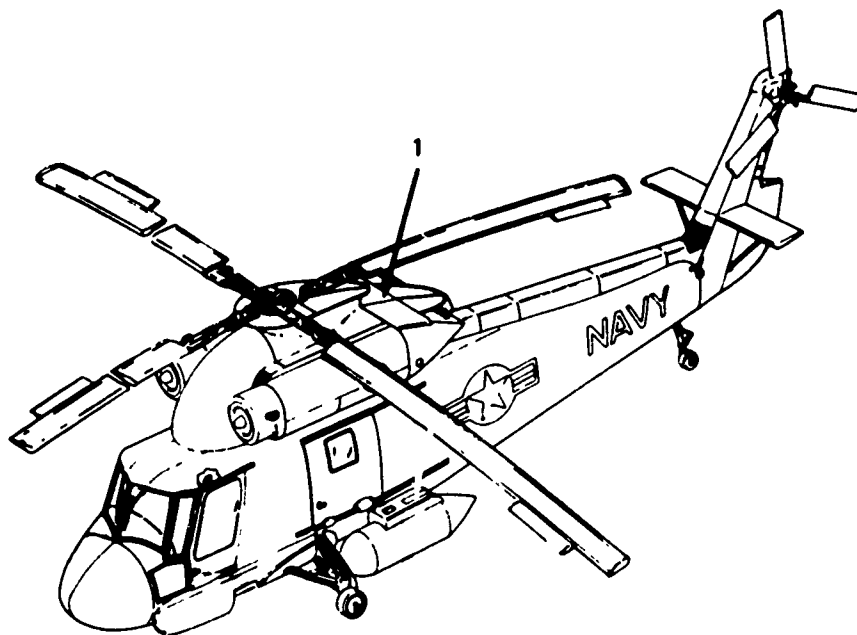
The Engine Oil Access Panel of the H-2 aircraft was the major problem area encountered, however, there was a greater variety of problem panels in this aircraft. The H-2C and H-2D aircraft have also reported Tail Rotor Cowlings problems which include a number of different panels. Figure C-1 shows the general arrangement of an UH-2C helicopter and Figure C-2 Summarizes the findings of the analysis of the NAVSAFECEN reports for the H-2C and H-2D helicopters.

#### Engine Oil Access Door

On the H-2C and the H-2D helicopters, the Engine Oil Access Panel has caused the most problems. These rectangular panels open horizontally on each side of the aircraft and are nicknamed "diving boards". The NAVSAFECEN compilation did not indicate a high frequency of in-flight openings of the Engine Oil Access Doors; but in each case reported, the doors became involved in the Rotor System. In two cases the aircraft were lost and the airmen were casualties due to Rotor unbalancing. The panels which are located just aft of the Rotor Blade Hub and just below the blades can be pushed together and closed without being secured. In one of the cases mentioned above, the accident investigation revealed that the panels were not fully locked. During the flight they vibrated open and finally separated from the aircraft on the landing approach. Realizing the critical nature of the panel, some of the active squadrons have made adjustments in their procedures. Some make a last minute, prior to flight, visual, double check to



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1 ENGINE OIL ACCESS DOOR  
2 PILOT AND RESCUE DOOR

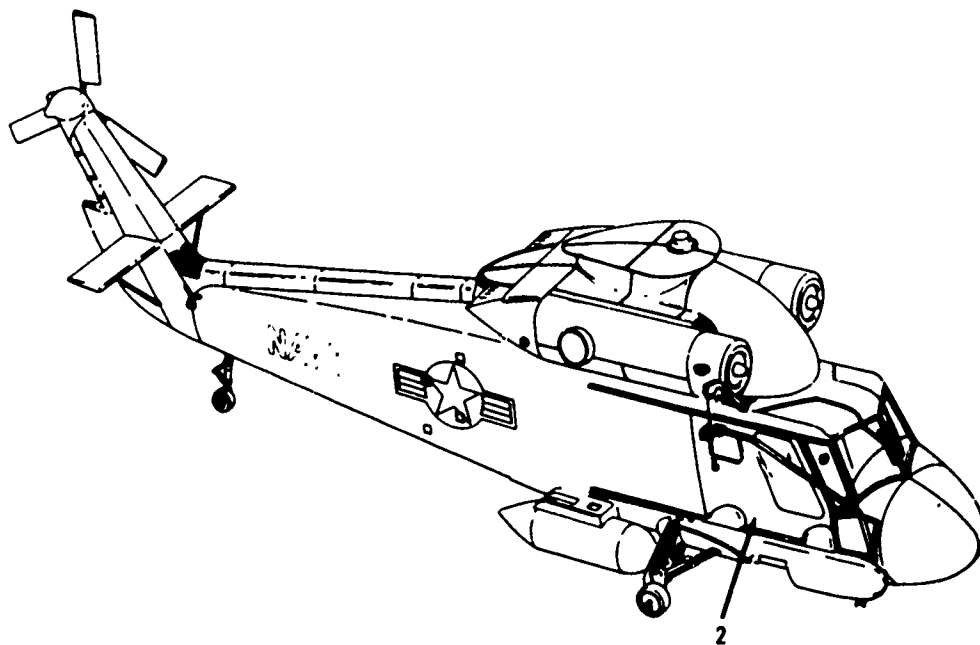


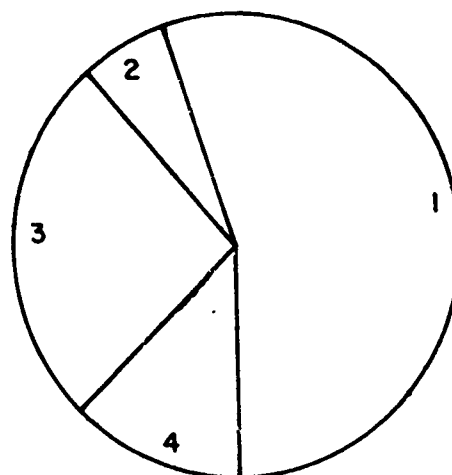
FIGURE C-1. UH-2C HELICOPTER



## ANALYSIS OF 62 INCIDENTS

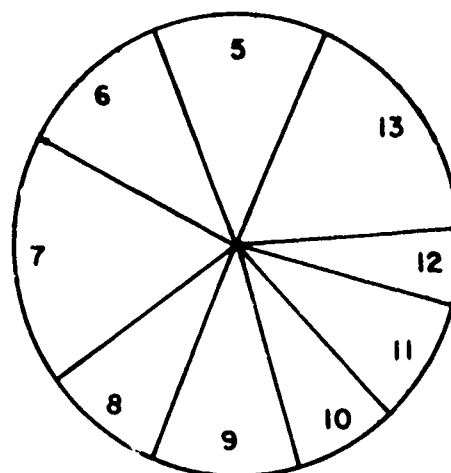
### CAUSES

1	MECHANICAL FAILURES	56.5
2	DESIGN DEFICIENCY	4.8
3	HUMAN ERROR	25.8
4	MAINTENANCE DISCREPANCY	12.9



### MAJOR ASSEMBLY AFFECTED

5	TRANSMISSION COWLING	11.3
6	CARGO DOOR	13.3
7	CABIN DOOR	17.0
8	CARGO DOOR WINDOW	9.4
9	TAIL ROTOR DRIVE SHAFT COWLING	11.3
10	TAIL(AFT) PYLON FAIRING	7.5
11	CABIN WINDOW	9.4
12	OIL ACCESS DOOR	3.8
13	OTHER	17.0



### CONTRIBUTING CIRCUMSTANCES

AIRCRAFT STATUS:	%
AIRCRAFT ON GROUND	16.1
AIRCRAFT IN FLIGHT	83.9
CREW PROCEDURES:	
IMPROPER PREFLIGHT	17.7
POOR FLIGHT PROCEDURES	3.2
UNREPORTED	79.1
PHYSICAL CAUSES	
FATIGUE	8.1
VIBRATION	9.7
UNREPORTED	82.2

FIGURE C-2. H-2C and H-2D HELICOPTER PANEL LOSSES



ascertain that these panels are fully secured. Secondly, the underside of this panel, which is visible from the ground, has been painted bright striped colors to maximize the probability of observation. Thirdly, since the panel can be closed and may not latch, some squadrons have adopted the policy that any time the panel is not fully open, it is fully closed and latched. During visits to squadrons, it was observed that a locking pin has also been added to the latch to insure that panels do not open.

#### Pilot Rescue Door

The Pilot's Rescue Door is an important problem area on the H-2 helicopters. In the NAVSAFECEN study, the Pilot's Rescue Door was the most frequently occurring in-flight discrepancy. The major causes were identified as the lower attachment structure/ bracket/slide track. Normal wear, vibration, and fatigue were all pinpointed as possible reasons for failure. A similar attachment and sliding design is used on doors on each side of the aircraft fuselage. The doors have adjustable plates which screw over a flange on the airframe. This design makes the entire door jettisonable for emergency egress. In evaluating existing designs, it appears to be more effective to securely restrain the door and design the windows with an emergency egress capability. On the aircraft inspected in the active squadrons, there was very little adjustment available, and the doors were adjusted to maximum tightness. However, there was still looseness in the door runners that could cause the door to tear free in the event of severe vibration and wind currents.



A P P E N D I X D

H-3 AIRCRAFT FINDINGS

General

The H-3 aircraft is a large, complex helicopter with many doors, windows and access panels. Figures D-1 and D-2 show the general arrangement of the H-3 aircraft. The major problem areas on this aircraft are (1) Cockpit Windows, (2) Cargo Door Window, (3) Engine Service Platform, and (4) Personnel Door. Lesser areas of concern are the Rotor Head Fairing (Beanie) and the Transmission Service Platform. Figure D-3 summarizes the findings of the analysis of the NAVSAFECEN reports on the H-3 helicopter. The Camloc quick-release fasteners used on the aircraft are reported as a problem by the maintenance people. These fasteners must be continually monitored and periodically replaced. Frequently, the exact size required is not available due to supply problems.

Cockpit Windows

Cockpit Windows encompass a variety of windows such as the Overhead Greenhouse Windows, Windshields, and Pilot's and Copilot's Sliding Windows. These components have been identified in the NAVSAFECEN and 3-M surveys. A number of cases of water leaking into the cockpit have caused electrical problems. The sliding, jettisonable windows on each side of the cockpit were cited for inadvertent release. These windows have popped out with their frame.



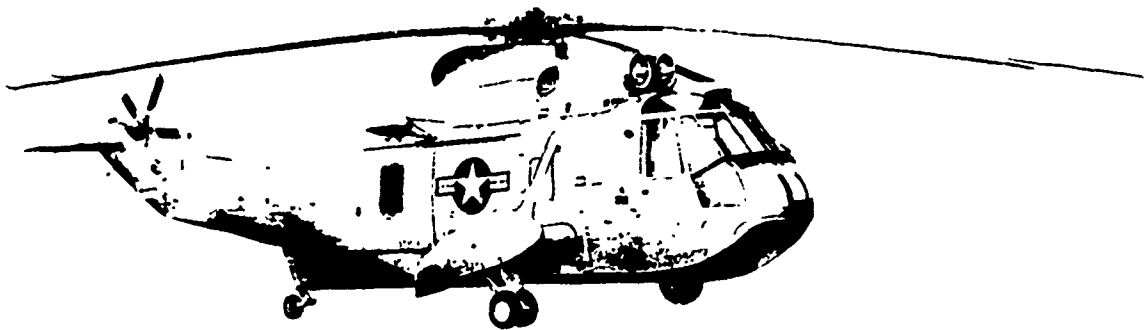
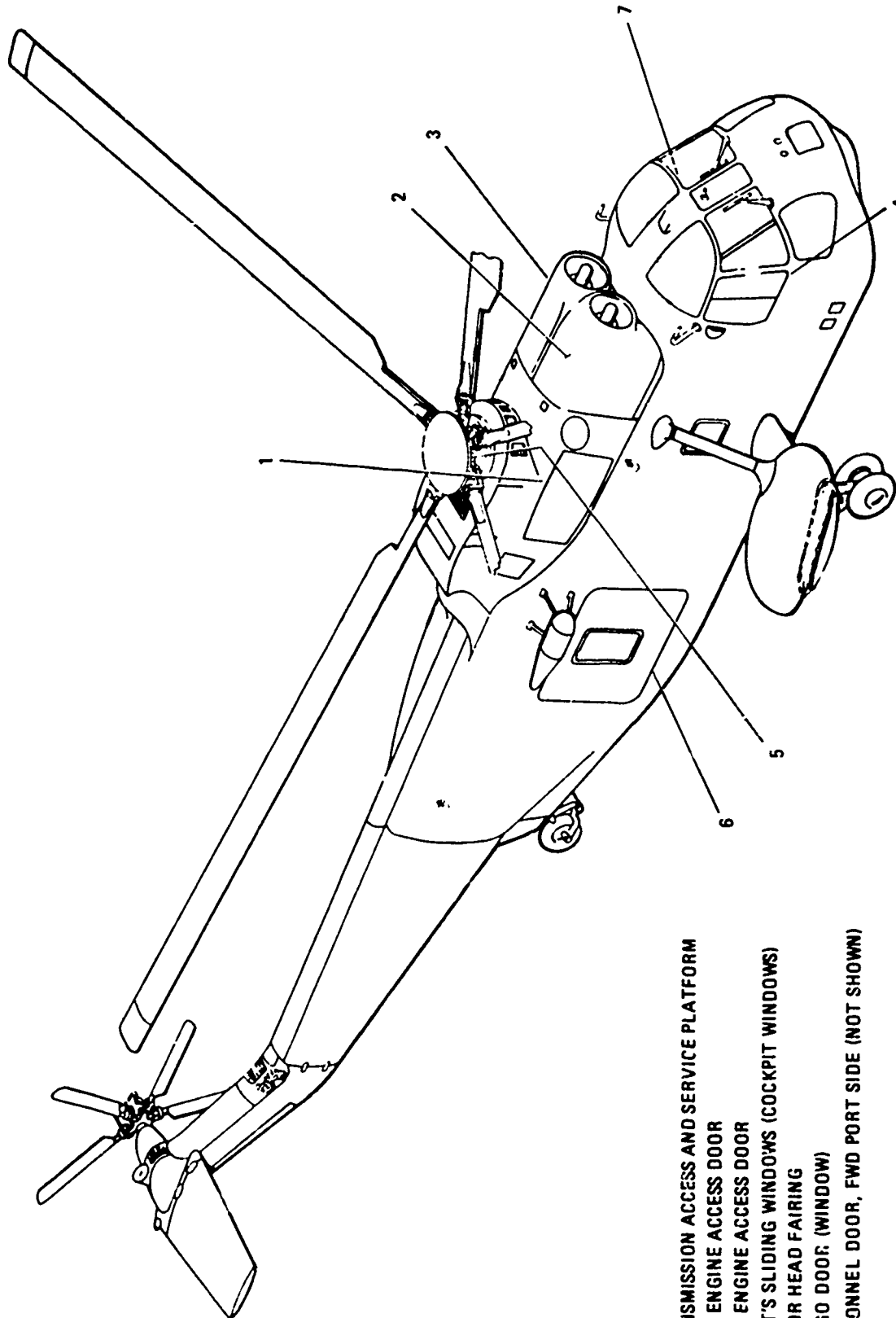


FIGURE D-1. H-3 HELICOPTER





- 1 TRANSMISSION ACCESS AND SERVICE PLATFORM
- 2 NO. 2 ENGINE ACCESS DOOR
- 3 NO. 1 ENGINE ACCESS DOOR
- 4 PILOT'S SLIDING WINDOWS (COCKPIT WINDOWS)
- 5 ROTOR HEAD FAIRING
- 6 CARGO DOOR (WINDOW)
- 7 PERSONNEL DOOR, FWD PORT SIDE (NOT SHOWN)

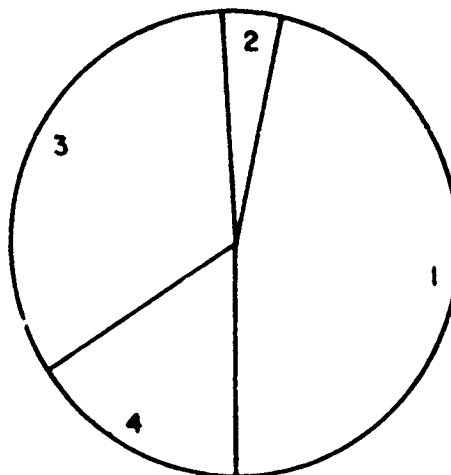
FIGURE D-2. H-3 HELICOPTER - GENERAL ARRANGEMENT EXTERIOR



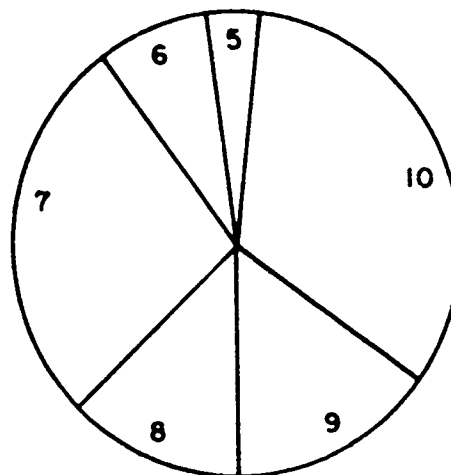
## ANALYSIS OF 166 INCIDENTS

CAUSES

1	MECHANICAL FAILURE	45.8
2	DESIGN DEFICIENCY	6.6
3	HUMAN ERROR	30.1
4	MAINTENANCE DISCREPANCY	17.5

MAJOR ASSEMBLY AFFECTED

5	CARGO DOOR	3.3
6	CABIN DOOR	11.1
7	CARGO DOOR WINDOW	24.8
8	CABIN WINDOW	15.0
9	ENGINE SERVICING DOOR	13.0
10	OTHER	32.8

CONTRIBUTING CIRCUMSTANCES

AIRCRAFT STATUS:	%
AIRCRAFT ON GROUND	8.4
AIRCRAFT IN FLIGHT	91.6
CREW PROCEDURES:	
IMPROPER PREFLIGHT	22.9
POOR FLIGHT PROCEDURES	0.6
UNREPORTED	76.5
PHYSICAL CAUSES:	
FATIGUE	1.8
VIBRATION	9.0
UNREPORTED	89.2

FIGURE D-3. H-3 SERIES HELICOPTER PANEL LOSSES



There is a significant amount of in-flight vibration experienced with the window open which in turn causes the locking handle to vibrate out of the locked position. Handle actuation is sometimes a problem but pilots prefer that the windows are not made more difficult to release. It is vital that this window release quickly and easily during an emergency.

#### Cargo Door Window

The NAVSAFECEN compilation indicated that loss of the Cargo Door Window (starboard emergency exit) is the most frequently occurring in-flight discrepancy. Unless this component fails, it generally does not require maintenance as shown by the low 3-M response.

Squadron interviews revealed that the Cargo Door Window has an emergency release handle which is shear wired. Overpressure, fatigue, vibration, normal wear and human error contribute to its failure. The window is relatively small and lightweight which minimizes the possibility of damage to the aircraft. Experience has shown that, because of the airflow around this aircraft, the starboard windows separate and tend to fly away harmlessly. Port-side panels, on the other hand, have a tendency to be blown back against the airframe and cause possible damage.

#### Engine Access Doors (Engine Service Platform)

The Engine Service Platform does not have a high frequency of failure but its size and proximity to the Rotor Blades make it hazardous if it opens in flight. The platform is secured to the airframe with two "J" hooks which are operated by a handle on the outside of the panel. This handle can close the platform flush



without the "J" hooks properly engaging. Pilots visually check the "J" hook engagement as part of their preflight inspection but the hooks are difficult to see. If last minute maintenance is required, the hooks may not be properly resecured. Some squadrons have installed a fix consisting of an external toggle latch; but this modification, which permits easier visual checking, has not been adopted as an approved engineering change.

#### Personnel Door (Port)

The lower Personnel Door is held by a slamming lock with a spring-loaded bolt on each side of the door. A handle is turned to a detent position to lock the bolts in a closed position. Wear of the slamming lock mechanism has caused the door to become unlocked. In addition, there is not enough overlap between the bolts and the striker plate on the airframe to insure locking. The H-46 and H-53 aircraft have similar Personnel Doors but they have about 1 to 1.5 inches of steel rod overlapping the striker plates. The H-3 upper Personnel Door is secured to the lower door by a single slamming lock. In-flight vibration causes these doors to open. The upper door displays a greater tendency to separate from the aircraft and has a greater potential to strike the Tail Rotor System. The lower door will generally stay with the aircraft. The 3-M compilation indicated that these doors required more maintenance actions than any other panel component on the H-3 aircraft.



## A P P E N D I X E

## H-46 AIRCRAFT FINDINGS

General

Figures E-1 and E-2 illustrate the H-46 helicopter and its access panels and doors. Figure E-3 summarizes the findings of the analysis of NAVSAFECEN reports on the H-46 helicopter. A problem which affects most of the H-46 access panels and doors is the lack of interchangeability of parts. Replacement parts often must be trimmed to fit. This problem was created when the airframe contractor failed to supply jigs to NARF Cherry Point. Parts may never fit properly and are likely to open in flight and possibly separate from the aircraft. The Forward and Aft Pylon Clamshell Doors and the Escape Hatches, are the panels most affected by this condition.

Forward Pylon Clamshell Doors

To clarify the terminology used, it is necessary to distinguish between the two large panels on each side of the forward pylon which are hinged at the bottom. Technically speaking, only the aft panel (Reference: Figure E-2, Annotation 7) is a clamshell and is referred to in the manuals as the Forward Pylon Clamshell. The forward panel (Reference: Figure E-2, Annotation 8) is referred to in the manuals as the Forward Pylon Access Panel. However, in common usage among the squadrons, both panels are referred to as Clamshells. This discrepancy made classifying the NAVSAFECEN reports difficult. However, since the largest percentage of reports which specify a part number refer to the forward panel, it is believed that most of the unspecified



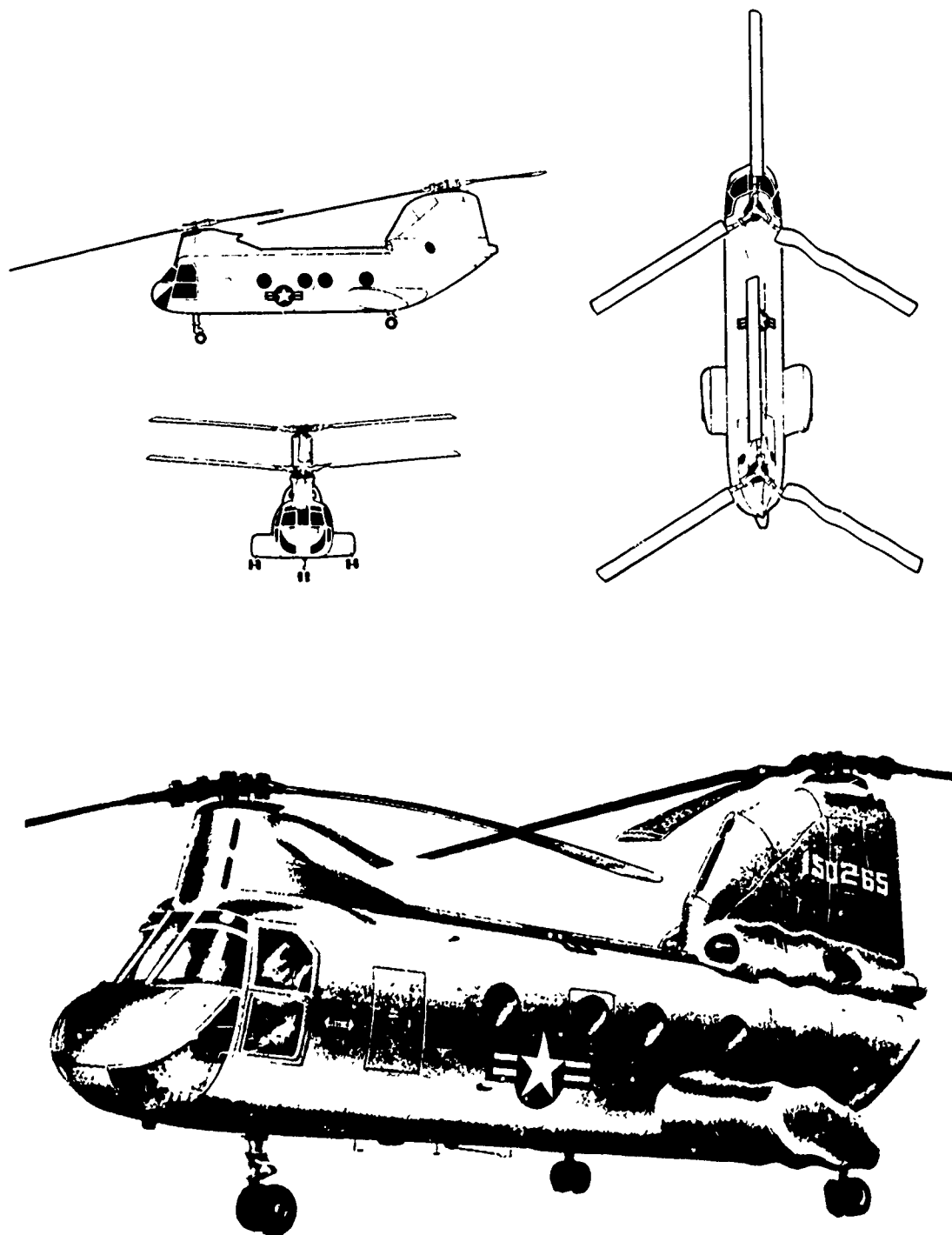


FIGURE E-1. H-46 HELICOPTER - GENERAL VIEW



- 1 DRIVE SHAFT TUNNEL FAIRING
- 2 DRIVE SHAFT TUNNEL DOOR
- 3 AFT PYLON FORWARD CLAMSHELL
- 4 AFT PYLON AFT CLAMSHELL
- 5 UPPER AFT PYLON FAIRING ACCESS DOOR
- 6 AUXILIARY POWERPLANT WORK PLATFORM ACCESS DOOR
- 7 FORWARD PYLON AFT CLAMSHELL
- 8 FORWARD PYLON FORWARD CLAMSHELL

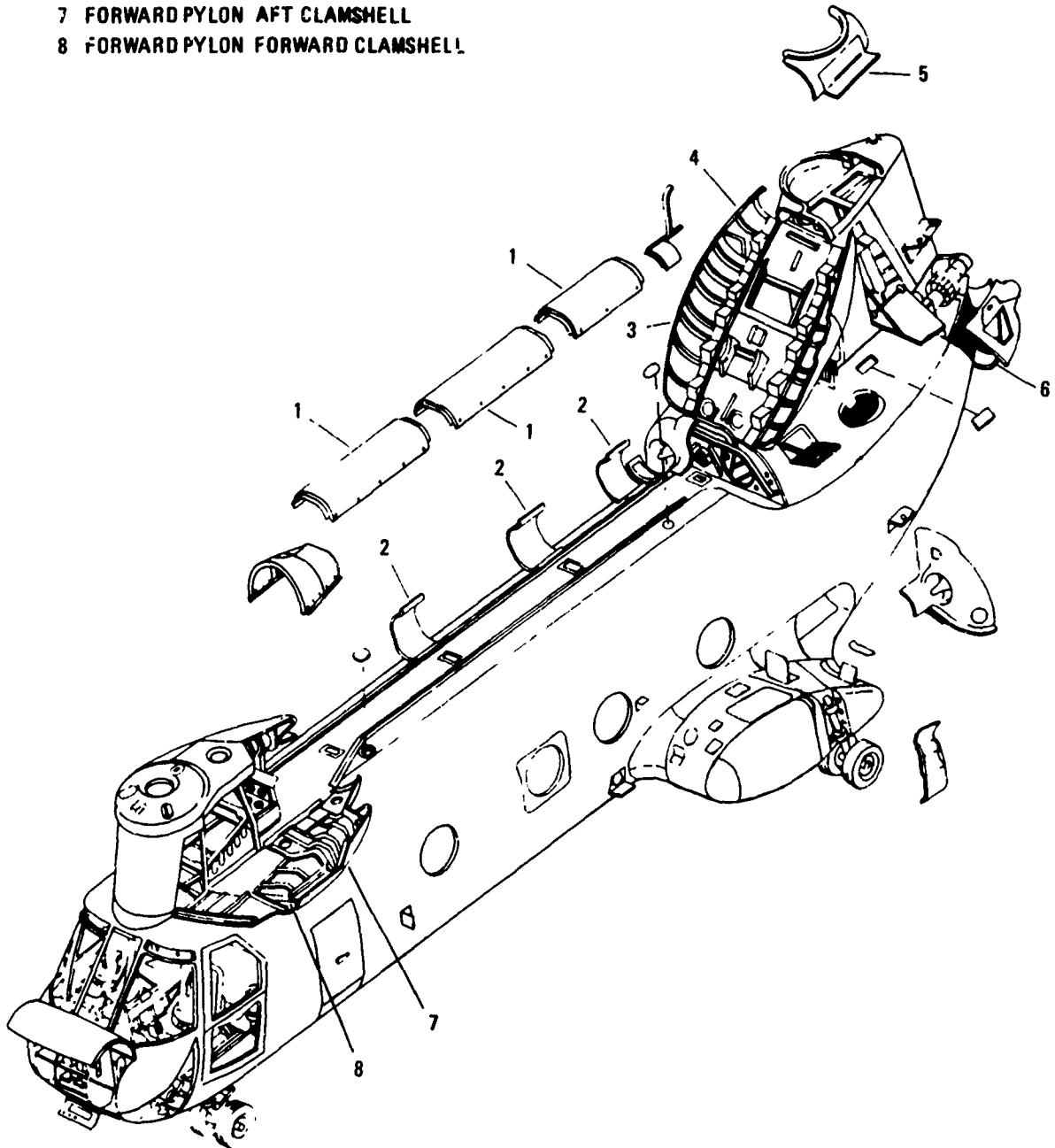


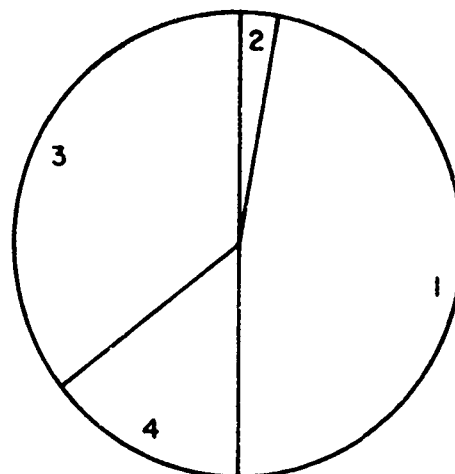
FIGURE E-2. H-46 HELICOPTER ACCESS DOORS



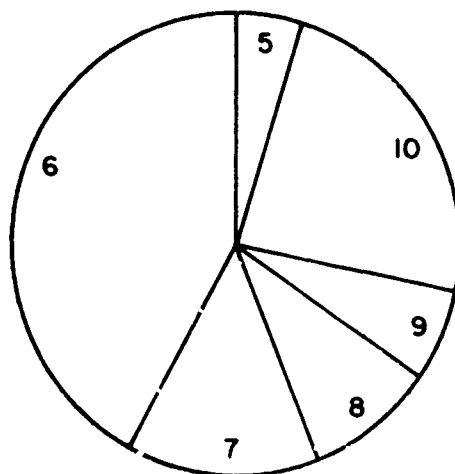
## ANALYSIS OF 168 INCIDENTS

CAUSES

1	MECHANICAL FAILURE	47.6
2	DESIGN DEFICIENCY	2.4
3	HUMAN ERROR	34.5
4	MAINTENANCE DISCREPANCY	15.5

MAJOR ASSEMBLY AFFECTED

5	FOD	4.3
6	CLAMSHELL DOOR	39.5
7	EMERGENCY ESCAPE HATCH	15.4
8	SWASHPLATE INSPECTION PANEL	11.1
9	SYNC. SHAFT INSPECTION COVER	8.6
10	OTHER	21.1

CONTRIBUTING CIRCUMSTANCES

AIRCRAFT STATUS:	%
AIRCRAFT ON GROUND	4.8
AIRCRAFT IN FLIGHT	95.2
CREW PROCEDURES:	
IMPROPER PREFLIGHT	28.6
POOR FLIGHT PROCEDURES	0.6
UNREPORTED	70.8
PHYSICAL CAUSES:	
FATIGUE	0.6
VIBRATION	10.1
UNREPORTED	89.3

FIGURE E-3. H-46 SERIES HELICOPTER PANEL LOSSES



cases are referring to the forward panel. The forward panel, for clarity, will then be referred to as the Forward Pylon Forward Clamshell.

Together the Forward Pylon Forward Clamshell and the Forward Pylon Aft Clamshell doors accounted for the largest number of reports from the NAVSAFECEN and 3-M data. The Forward Pylon Clamshell Doors received about equal emphasis with the Aft Pylon Clamshell Doors on the squadron visits. The squadrons placed most of the blame for the loss of the Forward Pylon Forward Clamshell Door on the warping of the leading edge. This panel becomes warped by maintenance personnel stepping outside the Work Platform area. Another cause suggested by some of the NAVSAFECEN reports and by some of the squadrons is the failure to properly secure the forward latch. It is difficult to see if the latch is properly secured because the latch is internal and located on the upper forward end of the panel. If the latch is not secured, the panel may flex enough to allow the windstream to get under the leading edge and open the panel. If the panel separates, it has the potential of striking either of the rotors.

Airframe Change (AFC) 213 provided kits to install modified Forward Pylon Forward Clamshell Doors which have larger Work Platforms and stronger reinforcing ribs especially on the forward edge. Squadron personnel have indicated that these modified doors are superior to the old doors and have reduced losses. Only 99 kits were provided by the AFC (two kits are required per aircraft) and these doors were not installed on all aircraft.



Aft Pylon Clamshell Doors

The Aft Pylon Clamshell doors (Reference: Figure E-2, Annotations 3 and 4) provide another problem area on the H-46. According to the NAVSAFECEN data, Aft Pylon Forward Clamshell Doors are lost more frequently than the Aft Pylon Aft Clamshell Doors. However, the aft doors are more dangerous to lose because of their proximity to the rotors. Those who cite the latches as the main cause say that flexing of the doors causes the latches to fail or that the latches are not properly adjusted causing the failure. Those who report the hinges as the main cause contend that the hinges become loose allowing excessive vibration in the doors and that either the hinges fail first followed by the latches failing, or that vibration causes the latches to fail.

One specific area cited is where the hinge is bolted to the door. There is a thin piece of metal on the door which the bolt passes through. Some of the squadrons have introduced a local fix to increase the thickness of this section because the hole has a tendency to elongate. Safety straps have been provided which fasten over the latches. They keep the latch from popping open as well as providing an additional latch. There are three straps on the Aft Pylon Clamshell Doors, two on the forward doors and one on the aft doors (There are also two straps on the Forward Pylon Aft Clamshell Door). The squadrons feel the straps have helped but this fix did not eliminate the real problem. Although this change has been in effect for some time, not all aircraft are equipped with the straps. NARF (Naval Air Rework Facility), Cherry Point is working on an ECP (Engineering Change Proposal) for the Aft Pylon Clamshell Doors.



Upper Aft Pylon Access Door (Swashplate Access Panel)

The Swashplate Access Panel (Reference: Figure E-2, Annotation 5) accounts for a significant number of losses. It does have a potential for striking the Rotor Blades (two out of the 21 NAVSAFECEN reports indicated this). The panel is relatively small and light and the possibility of seriously damaging the Rotor Blade and causing the aircraft to go out of control is small, but it does exist. The problem with the Swashplate Access Panel is that the Camloc fasteners are not securing the panel adequately. Failure could be caused by not using enough fasteners, the inability of the fasteners to withstand vibration, or incorrect fastener size.

Co-Pilot Escape Hatch

The Co-Pilot's Escape Hatch accounts for most of the escape hatch losses. Inadvertent actuations and failure to properly shear wire the handle have contributed to the losses of this hatch.

Drive Shaft Tunnel Fairings and Doors (Synchronous Shaft Inspection Panels)

The synchronous Shaft Inspection Panels (Reference: Figure E-2, Annotation 2) have been troublesome. They usually open in flight and hit the fuselage. They have separated from the aircraft but no cases of them striking the Rotor Blades have been reported. Fastener failure has been the problem. These panels become distorted from either coming open and being banged against the fuselage or by personnel walking on them. They can become so distorted that they rub against the synchronous shaft. Their frequent need for repair or replacement makes them an appreciable maintenance problem.



Auxiliary Powerplant Work Platform Access Door

A panel which was not reported in the NAVSAFECEN data but by the squadrons is the Auxiliary Powerplant Work Platform Access Door (Reference: Figure E-2, Annotation 6). The problem with this door is that the leading edge of the door becomes warped by personnel resting their heel on the door. The small gap created between the leading edge and door allows the windstream to get behind the door and separate it.



A P P E N D I X F

H-53 AIRCRAFT FINDINGS

General

The H-53 helicopter is a large, complex aircraft with many major and minor access panels. Figures F-1 and F-2 illustrate the H-53 aircraft. Figure F-3 summarizes the findings of the analysis of the NAVSAFECEN reports on the H-53 helicopters.

Cabin Windows

The NAVSAFECEN data indicates that the loss of Cabin Windows was a major problem on the "A" models. The marked decrease in the loss of Cabin Windows on the "D" models indicates that the sealant provided by AFC 126 has significantly improved the situation. The H-53E design solidly fixes the window to the airframe. This should stop Cabin Window losses; unfortunately, it compromises the emergency egress capability.

Rotary Wing Pylon Access Panel (Rotor Brake Access Panel)

The Rotor Brake Access Panel which is just aft of the Work Platform (Reference: Figure F-2, Annotation 2) stands out in all three data sources as being the major problem on the H-53. The NAVSAFECEN data shows the Rotor Brake Access Panel to be the constant contributor to in-flight incident reports (22.4% for all H-53's, 37.2% for H-53D). The 3-M data indicates it is the panel most frequently in need of maintenance action. This panel was also emphasized by squadron



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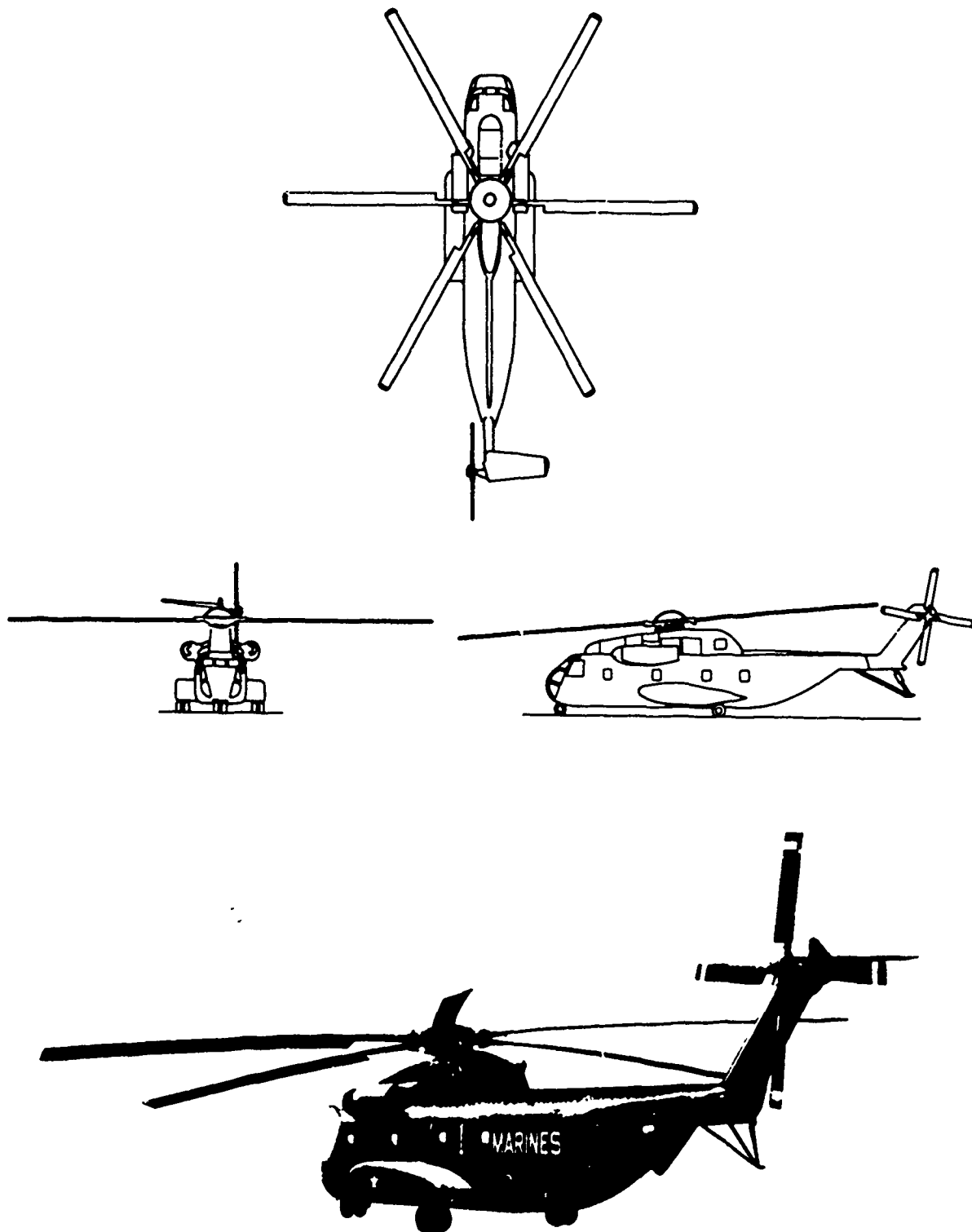


FIGURE F-1. CH-53A HELICOPTER - GENERAL VIEW



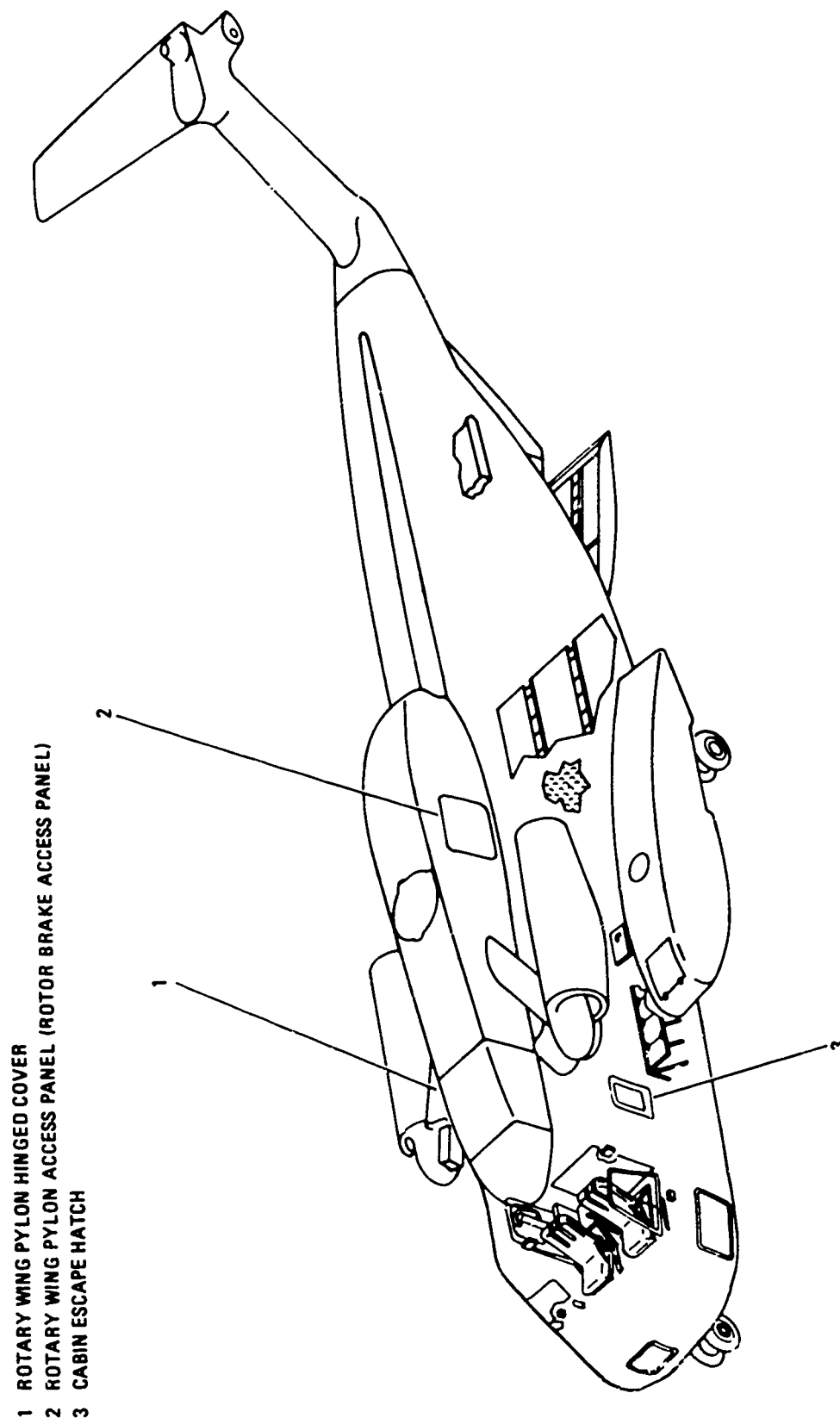


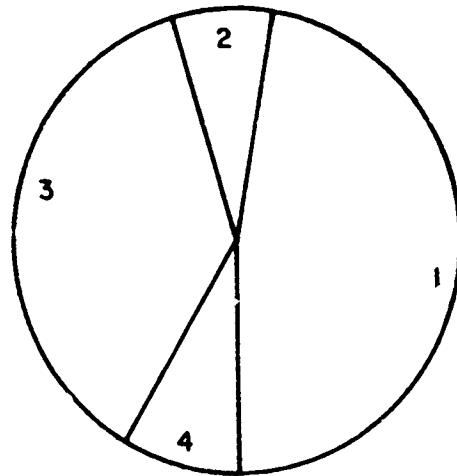
FIGURE F-2. CH-53A AIRFRAME EQUIPMENT AND FURNISHINGS



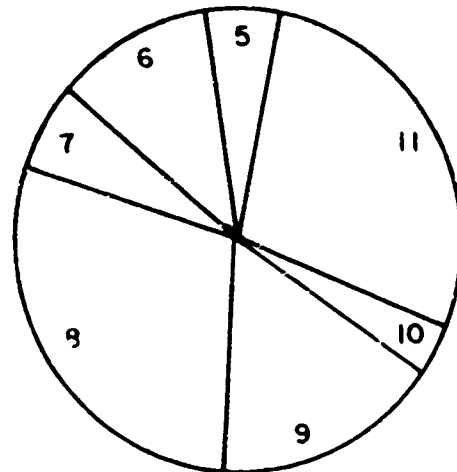
## ANALYSIS OF 149 INCIDENTS

CAUSES

1	MECHANICAL FAILURE	46.3
2	DESIGN DEFICIENCY	7.4
3	HUMAN ERROR	34.9
4	MAINTENANCE DISCREPANCY	11.4

MAJOR ASSEMBLY AFFECTED

5	ENGINE COWLING	7.4
6	CABIN DOOR	10.4
7	TAIL(AFT) PYLON FAIRING	5.2
8	CABIN WINDOW	29.6
9	ROTOR BRAKE ACCESS PANEL	17.0
10	OIL ACCESS DOOR	3.0
11	OTHER	27.4

CONTRIBUTING CIRCUMSTANCES

AIRCRAFT STATUS:	%
AIRCRAFT ON GROUND	10.7
AIRCRAFT IN FLIGHT	89.3
CREW PROCEDURES:	
IMPROPER PREFLIGHT	30.2
POOR FLIGHT PROCEDURES	0
UNREPORTED	69.8
PHYSICAL CAUSES:	
FATIGUE	0
VIBRATION	11.4
UNREPORTED	88.6

FIGURE F-3. H-53 SERIES HELICOPTER PANEL LOSSES



personnel. Problems with this panel are caused by its size, lack of weight and flexibility which make it susceptible to being torn off the aircraft if air is allowed to get under it. The Camloc fasteners which secure the Rotor Brake Access Panel do not keep the leading edge flush enough to prevent air from getting under the panel. The fasteners are too loose either due to wear in the receptacles or an improper size being used. The frequency of loss of the Rotor Brake Access Panel is alarming considering this panel's potential of hitting the Rotor Blades. Because of the windstream around the aircraft, the port panel is more apt to strike the Rotor Blades than the starboard panel. Fortunately, the starboard panel is lost more frequently than the port panel.

IAFC (Interim Airframe Change) 207 was introduced to provide a plate which overlaps the upper forward corner of the Rotor Brake Access Panel. The plate is attached to the Work Platform which is located just forward of the Rotor Brake Access Panel. The panel is fastened to the Rotor Brake Access Panel using two existing Camloc fasteners. Although the root of the problem is not corrected, the Airframe Change will help prevent losses of the panel by keeping the leading edge flush. This panel should be watched closely to see if the Airframe Change is adequate or needs further change.

#### Hydraulic Access Panel

The Hydraulic Access Panel has a history of loss and its proximity to the Rotor makes a loss dangerous. The problem has been identified as the hinge placement on the aft edge making it easy for a windstream to catch the panel if the fasteners fail or if the panel is not secured properly. Some of the aircraft now have the panel hinged on the leading edge thereby reducing the chance of loss.



The Hydraulic Access Panel and the Work Platform are a sandwich construction of fiber glass exterior, wood center and metal interior. Hydraulic oil, which frequently covers the aircraft, can seep through any cracks there might be in the fiber glass and deteriorate the wood. As the wood deteriorates, it gets spongy and eventually breaks. Although the three materials have different coefficients of thermal expansion and consequently are subject to layer separation, only 6% of the reported cases involved these panels. Thermal expansion did, however, cause continual maintenance problems.

#### Cabin Escape Hatch

The Escape Hatch (Reference: Figure F-2, Annotation 3) accounted for nine percent of the incidents reported in NAVSAFECEN reports. The mass of the Escape Hatch makes it a potential hazard because it would cause extensive damage to the Rotors if it was to strike them (No such occurrence has been reported). The hatch would also cause personnel or property damage if it fell in a populated area. Frequently the hatch is removed for better in-flight cabin ventilation, for weapon installation or for gravity fueling of internal tanks. Frequent removal causes the hatch to become insecure. With age the latching mechanism flexes allowing the securing pins to drop out of their guides. Also it is difficult to see if the pins have properly seated in the side of the frame. If a crewmember attempts to remove the hatch in-flight, the wind blast will most likely tear it from his grasp. Squadron personnel have suggested the possibility of forward-hinging the hatch to improve the ability to secure the hatch while still retaining the opening capability. The design philosophy of the H-53E is to maximize commonality of parts with earlier models. Consequently, the H-53E port Emergency Escape Hatch is designed the same as the earlier models.



Rotary Wing Pylon Hinged Cover (Hinged Doghouse Cover)

The Hinged Doghouse Cover (Reference: Figure F-2, Annotation 1) represents only 2.2 percent (3 cases) of the NAVSAFECEN reported incidents, although each case has resulted in the cover hitting the Rotor Blades. Two of the three reported cases were due to improperly securing the cover prior to flight. The cover is hinged on its leading edge, and even if the cover is not secured it should not open in level flight. Certain maneuvers could cause it to open and hit the Rotors. The squadrons visited have indicated that it sometimes takes an excessive amount of time to close and secure the hinged cover. This problem is caused by the cover being large and flexible and the frame being very susceptible to distortion.

Tail Pylon Panels

The Tail Pylon Drive Shaft Cowlings have some tendency to come off due to Camloc fasteners missing and/or failing. The squadrons visited indicated they had lost a few "chip detectors" (Tail Gear Box Drain Access Doors) although there were no reports of this in the NAVSAFECEN printout. There is a tendency for the fiber glass to rip out around the screws which secure the "chip detector". These covers are now being received at the squadrons with washers embedded between layers of the fiber glass. This modification appears to have decreased incidents of cover losses. The Tail Pylon Drive Shaft Cowlings and the "chip detector" usually separate from the aircraft without striking the Rotor blades.